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DESIGN AND FABRICATION OF BLACK BOX EJECTION SYSTEM FOR A CIVIL TRANSPORT AIRCRAFT

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ABSTRACT

Flight data recorder (FDR) and Cockpit voice recorder (CVR) are very important and play vital role in the investigation of the flight accidents. These are also used to locate the aircraft crash site and the circumstances in which the aircraft is crashed. There are many cases where the black box location is not identified. This project reveals simple, economic and safe ejection of FDR in case of aircraft crashes. A simple Pneumatic system with air bottle is used to operate both the hatch door and the ejection system. After the ejection, a parachute is used to land the black box little far away from the crash site debris in a safest location. Three sensors are installed on the aircraft to sense the temperature, deformation and frequency of vibration of the structure. The system is activated and ejection process takes place only when abnormal values i.e. temperature, deformation and frequency of vibration are recorded.

***KEYWORDS:** Flight Data Recorder, After the Ejection & Vibration are Recorded*

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Original Article

INTRODUCTION

An aircraft's flight recorders are an invaluable tool for investigators in identifying the factors behind an accident. Recorders usually comprise two individual boxes: the Cockpit Voice Recorder (CVR) and the Flight Data Recorder (FDR). Popularly known as 'black boxes', these flight recorders are in fact painted orange to help in their recovery following an accident

Figure 1.1: Aircraft Black box

Several attempts have been made to address this problem of finding aircrafts that are lost over large water bodies. Some officials fear that relying solely on ejectable flight recorders would take attention and resources away from the search for deep-water wreckage and bodies that can also help solve air crashes and ease the suffering of families. Boeing has taken the opposite stance over the use of deployable recorders, arguing that the majority of its black boxes are recovered within 30 days, also citing instances where these alternative recorders have failed on

military aircraft. The crash of an Egypt Air jet has strengthened the case for eject able “black boxes” that are launched out of an aircraft in an accident, making them easier to find, the most senior engineer at Airbus has said.

Ejectable or “deployable” recorders would separate from the tail during a crash and float in the water while emitting a distress signal. Recommended by investigators after an Air France A330 jet crashed in 2009, the idea was again discussed after the disappearance of Malaysia Airlines flight 370in March 2014. The United Nations’ aviation agency, the International Civil Aviation Organization, has called for key data to be recoverable in a “timely manner” from aero planes delivered after 2021.

It will be left to airlines and manufacturers to decide how to meet the goal – whether through deployable recorders or other technology such as new homing methods or data streaming. Deployable recorders have long been used in the military. But some in the industry have expressed doubts about their safe use on civil airliners, saying they could be ejected accidentally and introduce new risks

There have been various patents filed in order to address this problem. One such patent United States patent, patent number US 3140847 approved on July 14, 1964 in which the inventor came up with the idea of ejecting the black box with the help of a rocket charge that would eject the black box out of the aircraft from the tail cone which would then be brought down to the surface with the help of a small parachute that is included in the design of the black box. This design was used in various military aircrafts of that era. Even though this system was included in several aircrafts, it cannot be included in our system because it is not safe to use an explosive charge in a civil transport aircraft, since any small error can result into a catastrophe. This is the reason why Boeing is reluctant in not including such systems in their aircrafts. The other approach was the ejection of two locator beacons one that would be attached to the skin of the aircraft and the other that would float to the surface. These two beacons would transmit signals to each other. The location of the surfaced beacon would guide the rescue team to the location of the submerged plane. This would eventually result in the finding of the black box. Taking this approach into consideration, a system has been designed and fabricated that would eject the black box out of the aircraft and to include a flotation device in the black box that would allow it to float to the surface in case of an accident that would drown the aircraft.

Black box specifications

A typical FDR has the following dimensions:

Height =16 cm

Width =12.7 cm

Depth = 50 cm

Weight = 4.8 kg

Table 1: Weight of the FDR

Material	Weight of the FDR (Kg)
Preliminary Materials	6.7010
Carbon Epoxy	4.8065
E-Glass Epoxy	4.9841

Ejection Mechanisms

The most common ejection system used in the aircraft is aircraft seat ejection system used in a fighter aircraft to save the pilot's life in case of a crash /accident.

Figure 1.2: Aircraft Seat Ejection

In aircraft, an ejection seat or ejector seat is a system designed to rescue the pilot or other crew of an aircraft (usually military) in an emergency. In most designs, the seat is propelled out of the aircraft by an explosive charge or rocket motor, carrying the pilot with it. The concept of an ejectable escape crew capsule has also been tried. Once clear of the aircraft, the ejection seat deploys a parachute. Ejection seats are common on certain types of military aircraft. The "standard" ejection system operates in two stages. First, the entire canopy or hatch above the aviator is opened, shattered, or jettisoned, and the seat and occupant are launched through the opening. In most earlier aircraft this required two separate actions by the aviator, while later egress system designs, such as the Advanced Concept Ejection Seat model 2 (ACES II), perform both functions as a single action

2.0 System design

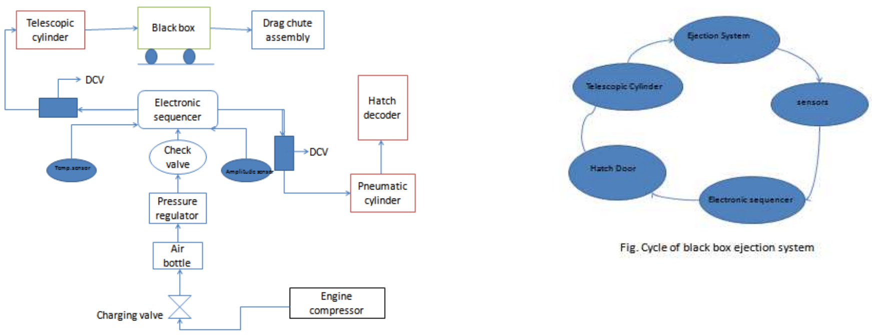

Figure 1.3: Block Diagram of Ejection System

The three sensors work in collaboration with each other and will control the system. The aircraft sensors as shown in the diagram below

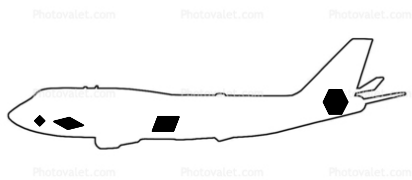

Figure 1.4: Sensor Locations

- Inertia/G sensor.
- Structural sensor.
- Immersion sensor.
- Deployable black box

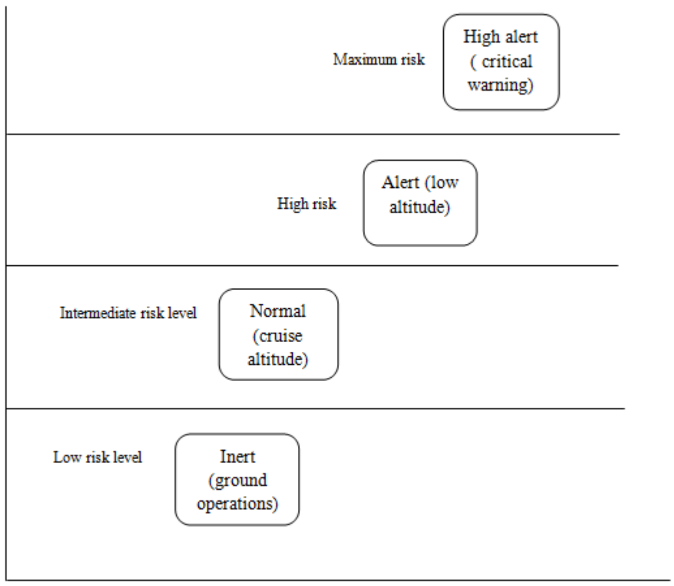

Figure 1.5: Risk Assessment

The sensors detect the threat and they will calculate the risk and when there is imminent danger, they will activate the system. Their assessment is as shown in the below mentioned chart. During ground operations and other such normal activities, the systems remain inert i.e. they assess the risk as to be minimal. While in normal cruise flight, the sensors shall be at intermediate risk level. In low altitude flying, the sensors will be at high risk level when thespeed is not that as corresponding to which would be at that flight level. The systems would be at high risk level if the aircraft is vertically falling to the ground or is travelling at speeds with an angle that cannot be undone and when the sensors sense danger

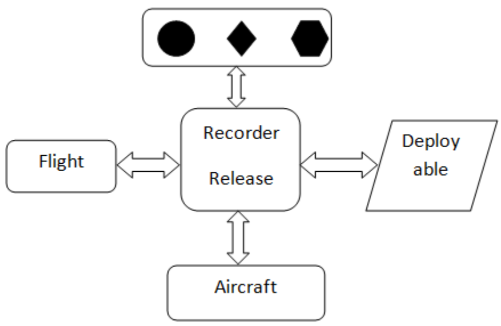

Figure 1.6: Initiation of the Mechanism

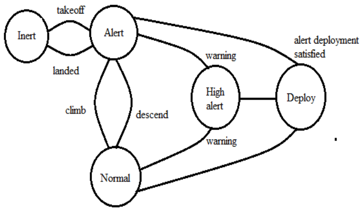

Figure 1.7: Deployment

The system shall take input from all the instruments installed in the aircraft that would help it to determine a situation that is deemed to end with an accident and in collaboration with the sensors fitted will initiate the ejection sequence

The system consists of the following components.

- Reservoir.
- Pneumatic piston cylinder.
- Black box.
- Guide rails.
- Ejection door

The reservoir would be filled with air taken from the aircraft high pressure system used for landing gear etc. typically a value of 3100 psi. This would be connected to a solenoid valve whose purpose is to guide the pressurized air into the pneumatic cylinder. when needed for operation. This solenoid valve will be integrated with the sensors such that their activation will initiate the ejection sequence of the black box. We have kept the ejection door at the bottom because the drag effects are minimal at that point. The door will be held in position with the help of four fasteners which will break when the black box hits them and will allow for the easy ejection of the black box. Once the black box is out of the aircraft, a pressure sensor will activate the piercing mechanism of the carbon dioxide cylinder fitted in the black box which will fill the nylon bag and will make the black box to surface. By this time the Emergency Locator Transmitter (ELT) will be activated and will send the signals which will allow the search and rescue team to locate it.

deployment

criteria

satisfied

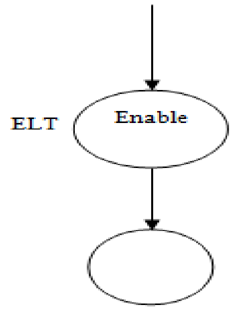

Figure 1.8: Enabling ELT

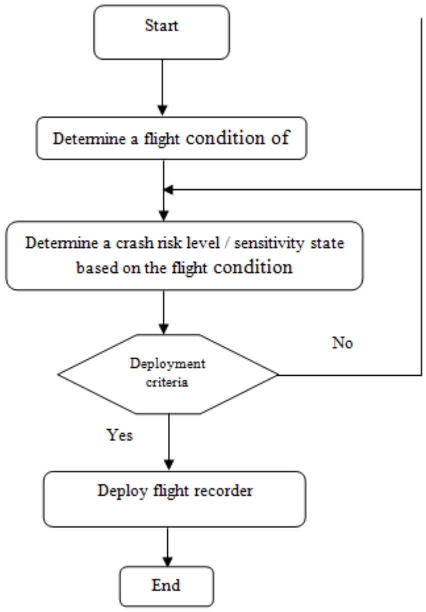

Figure 1.9: Flowchart of the Ejection Sequence

The force exerted by the pneumatic cylinder can be calculated as

$F = p\ \pi\ d^2 / 4$

$P = 10^5\ N/m^2$

D = 20 mm /.02 m

Therefore,

$F = 10^5 * \pi *.02^2 / 4$

F = 31.4 N

This is the force with which the pneumatic cylinder of our project will push the black box out.

Fabrication

Plywood is made of several thins layers, or 'plies' that are laminated together. The layer structure leads to more uniform properties than solid wood, since the effects of grain anisotropy are minimized. The typical properties of plywood are as given below

Properties of Plywood

Mechanical Properties:	Metric	English
Tensile Strength, Ultimate	31.0Mpa	4500psi
Flexural Modulus	9.30 GPa	1350ksi
Compressive Yield Strength	31.0 - 41.0 MPa	4500-5950psi
Shear Modulus Modulus of elasticity	0.170 GPa [1.01,1.24]*10^6 lb in^-2	24.7ksi
	0.700 GPa	102ksi
Shear Strength	1.90 MPa	276psi
	6.20 MPa	899psi

Selection of Components

- Double acting pneumatic cylinder - 1 no.
- Manually operated solenoid valve - 1 no.
- Quarter inch brass silencers – 2 nos.
- Quarter inch hose joint 6mm dia – 2 nos.
- Quarter inch hose joint 8mm dia – 2 nos.
- Quarter inch joiner 8mm dia – 1 no.
- 6mm dia hose tube – 5 meters.
- Teflon tape – 1 no.
- 1 inch ‘U’ clamps – 2nos.
- 2 and half inch screws – 12 nos.
- Structural sensor – 1no.
- Immersion sensor – 1 no.
- Inertia or G sensor – 1 no.
- Self inflating tube – 1 no.
- CO_2 cartridge 33 gm – 1 no

Figure 2.1: Self Inflating Raft

Figure 2.2: Inertia Sensor

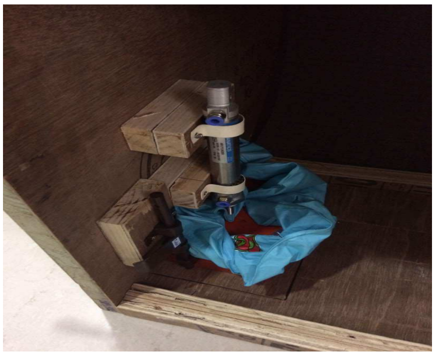

Figure 2.3: Pneumatic Cylinder and Guide Rails

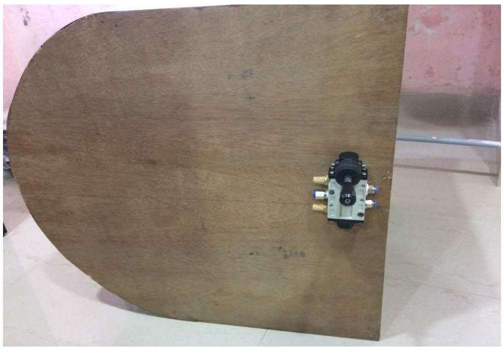

Figure 2.4: Solenoid Valve on the Model

Figure 2.5: System Prototype

CONCLUSIONS

The Design and Fabrication of black box ejection system for a civil transport aircraft has been carried out in this work the System separates the black box from the aircraft and ejected out of crashed aircraft debris**.** If the aircraft crash above the water bodies, it floats on the water after it is separated from the aircraft. In this way, it is easy to locate the crash site and trace the aircraft easily. The black box ejection system for a civil transport aircraft is simple, easy to install on the aircraft and the maintenance cost is less.

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